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Horng

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(54) **ADVECTION FANS**

(75) Inventor: **Alex Horng**, Kaohsiung (TW)

(73) Assignee: **Sunonwealth Electric Machine Industry Co., Ltd.**, Kaohsiung (TW)

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F04D 29/42	(2006.01)
F04D 29/40	(2006.01)
F04D 29/60	(2006.01)

(52) **U.S. Cl.**

CPC ***F04D 17/04*** (2013.01); ***F04D 25/0653*** (2013.01); ***F04D 29/4226*** (2013.01); *F04D 25/06* (2013.01); *F04D 25/064* (2013.01); *F04D 25/0606* (2013.01); *F04D 25/0646* (2013.01); *F04D 29/403* (2013.01); *F04D 29/602* (2013.01)

(58) **Field of Classification Search**

CPC F04D 17/04; F04D 25/06; F04D 25/064; F04D 25/0606; F04D 25/0646; F04D 25/0653; F04D 29/403; F04D 29/4226; F04D 29/602

USPC 417/423.1, 423.7, 423.12, 423.14, 161, 417/201, 354, 352, 353; 310/156.32–156.37, 268, 71, 67

See application file for complete search history.

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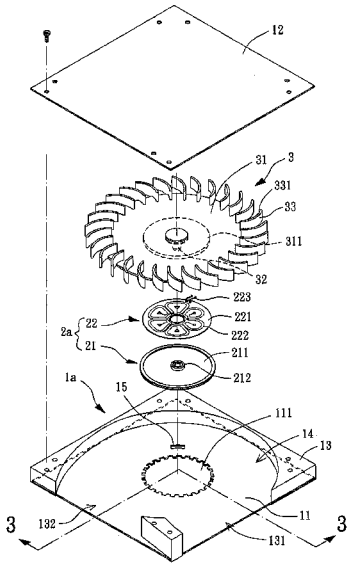
Primary Examiner — Devon Kramer
Assistant Examiner — Stephen Mick
(74) *Attorney, Agent, or Firm* — Alan D. Kamrath; Kamrath IP Lawfirm, P.A.

(57) **ABSTRACT**

An advection fan includes a housing having a metal housing base and a closure member. A lateral wall is arranged between the metal housing base and the closure member and includes an air inlet and an air outlet. A horizontal air passage is defined between the metal housing base and the closure member. The metal housing base includes an engagement section. A stator includes a coil unit embedded in or abutting and attached to the engagement section of the metal housing base. The coil unit abuts the engagement face of the metal housing base. The coil unit includes a substrate and at least one coil formed on a surface of the substrate by a printing circuit or electroforming process. An impeller is rotatably coupled to the shaft tube of the stator. A gap is formed between the impeller and the coil unit of the stator.

34 Claims, 10 Drawing Sheets



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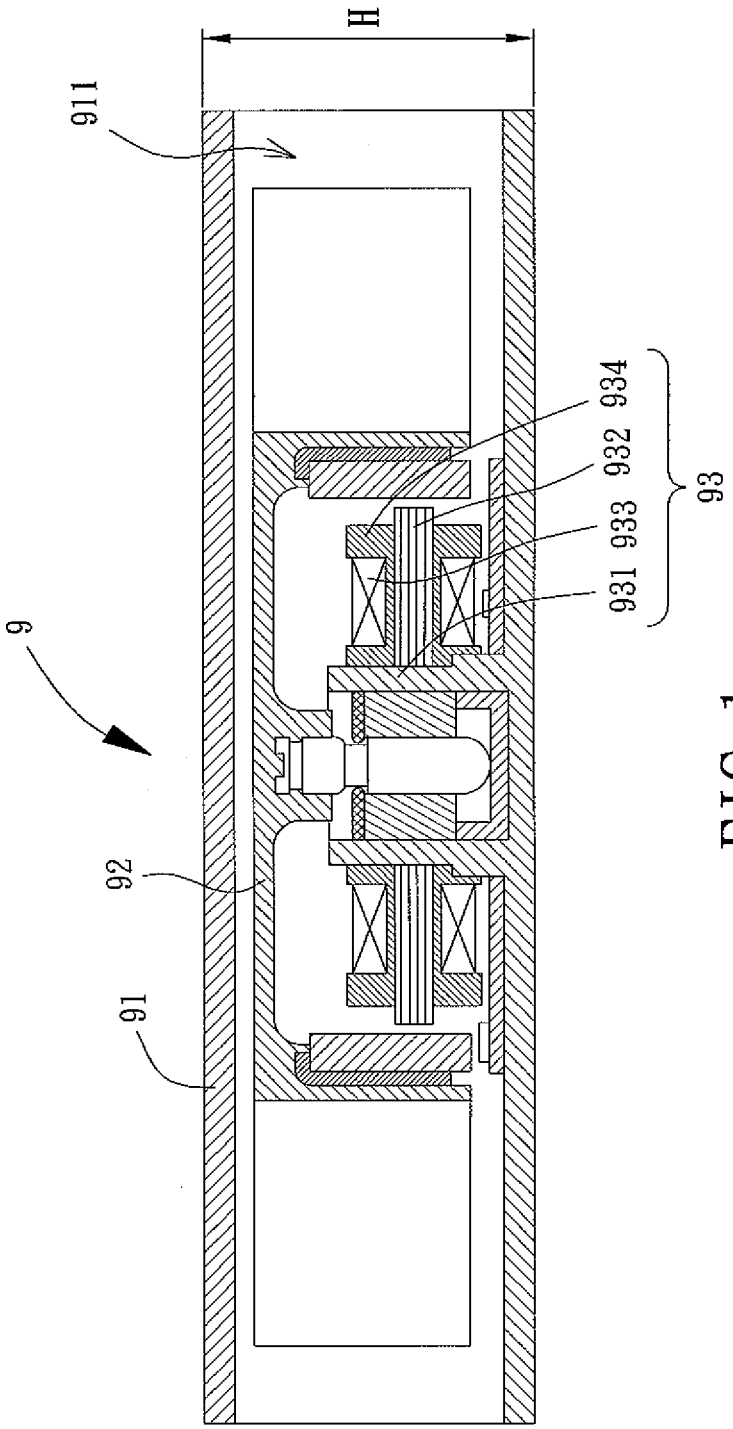
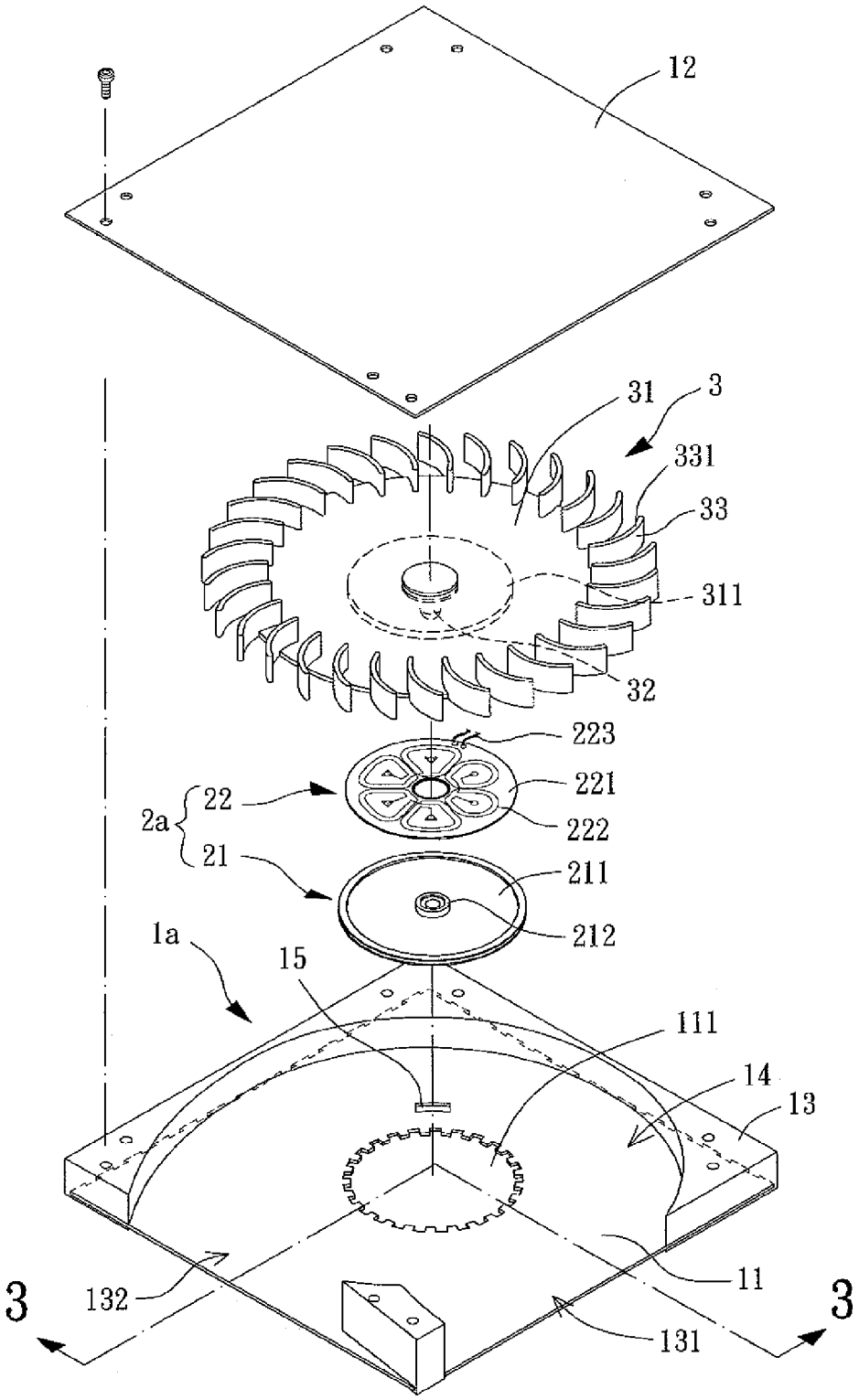


FIG. 1
PRIOR ART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311
32
223
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11
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132
131
3

FIG. 2

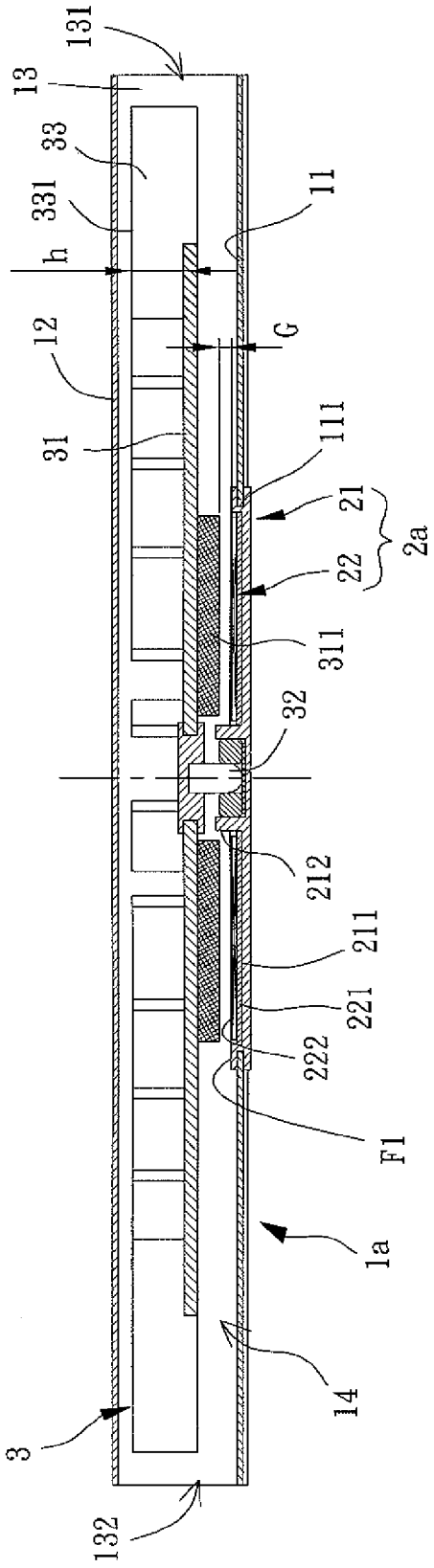
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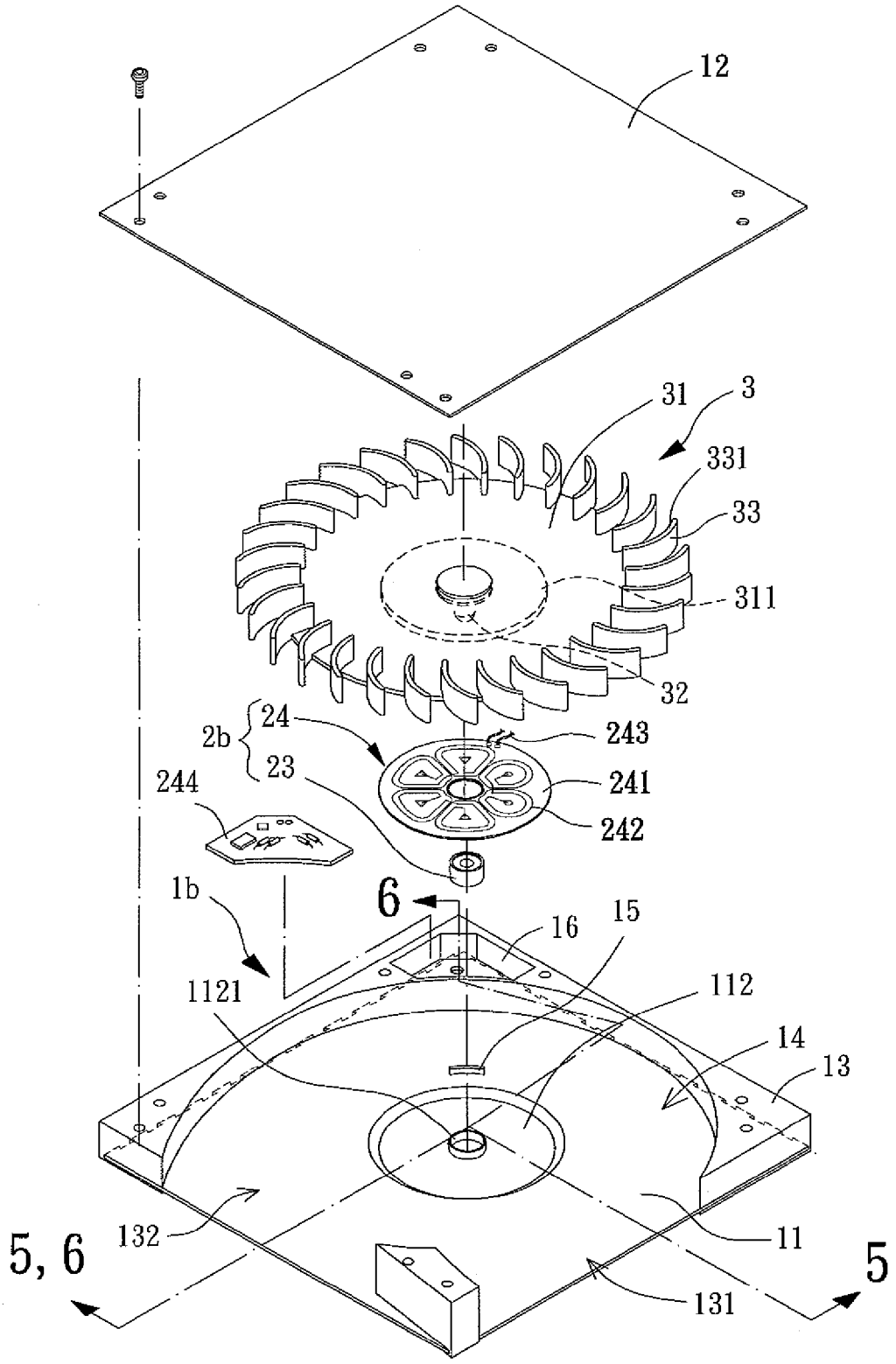
FIG. 3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132
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5, 6
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FIG. 4

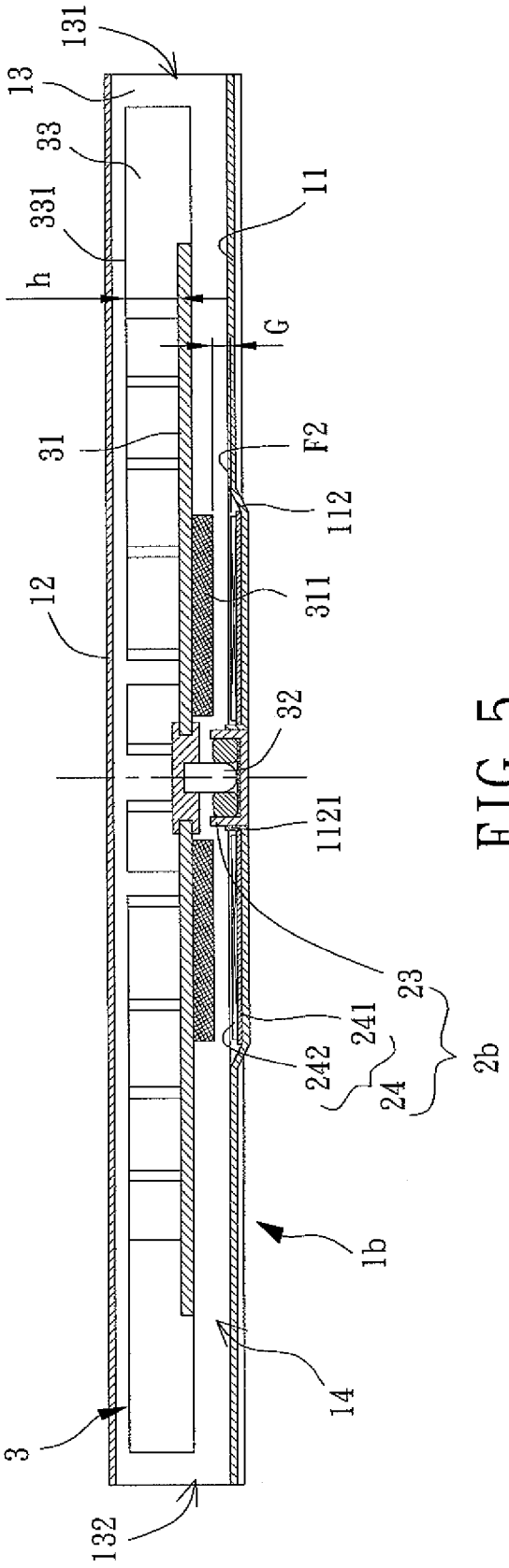
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FIG. 5

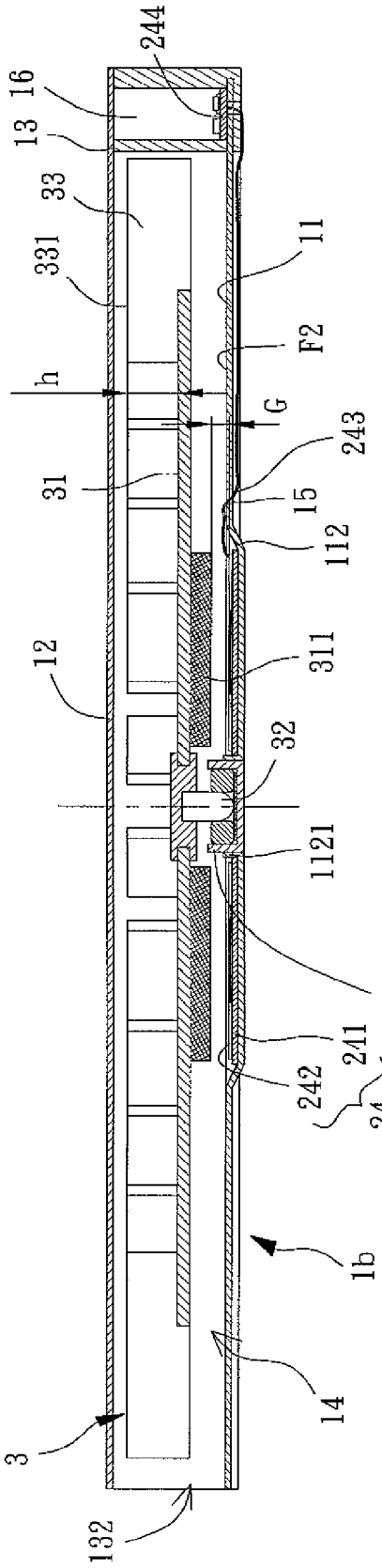
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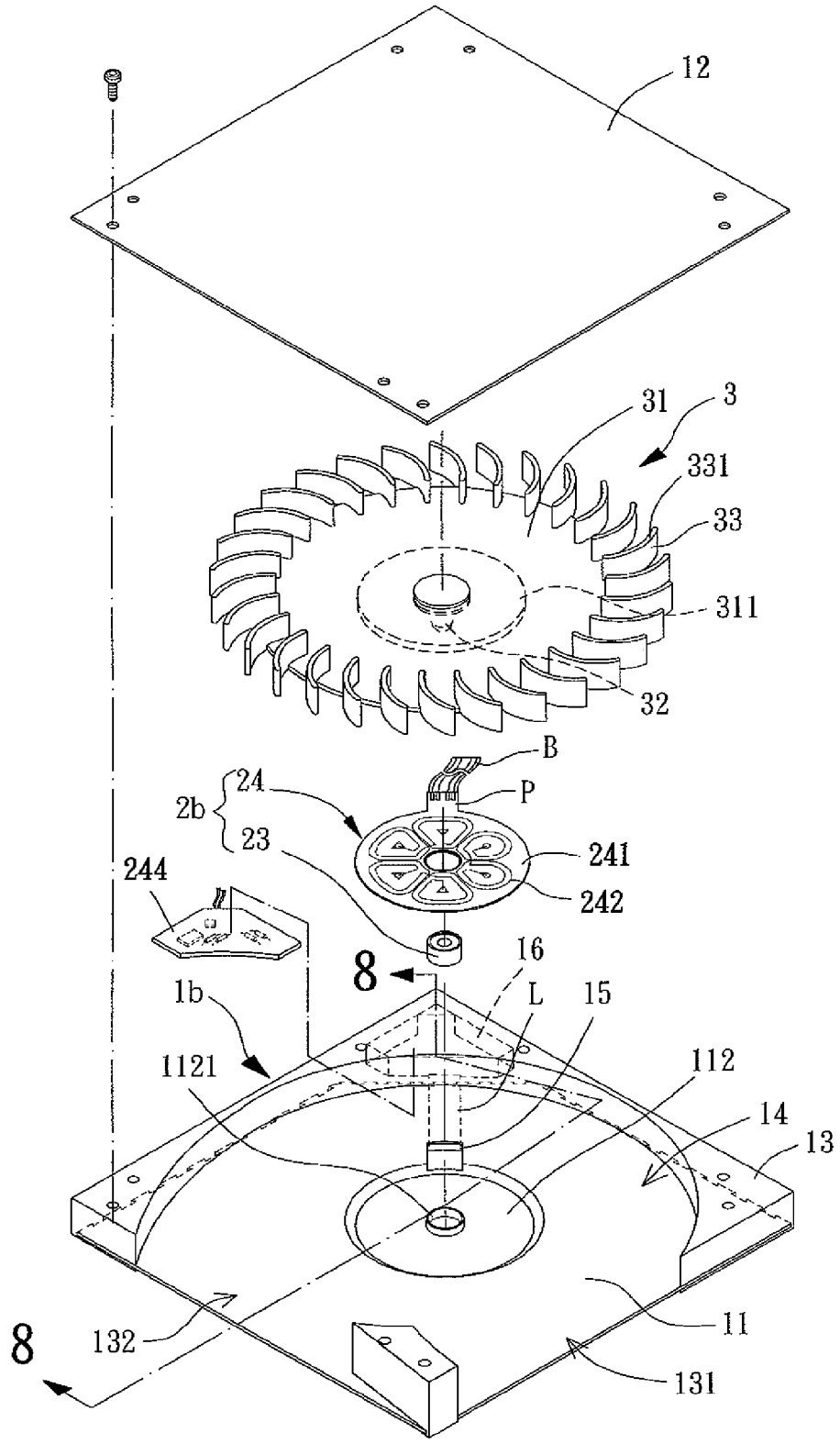
FIG. 6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11
131

FIG. 7

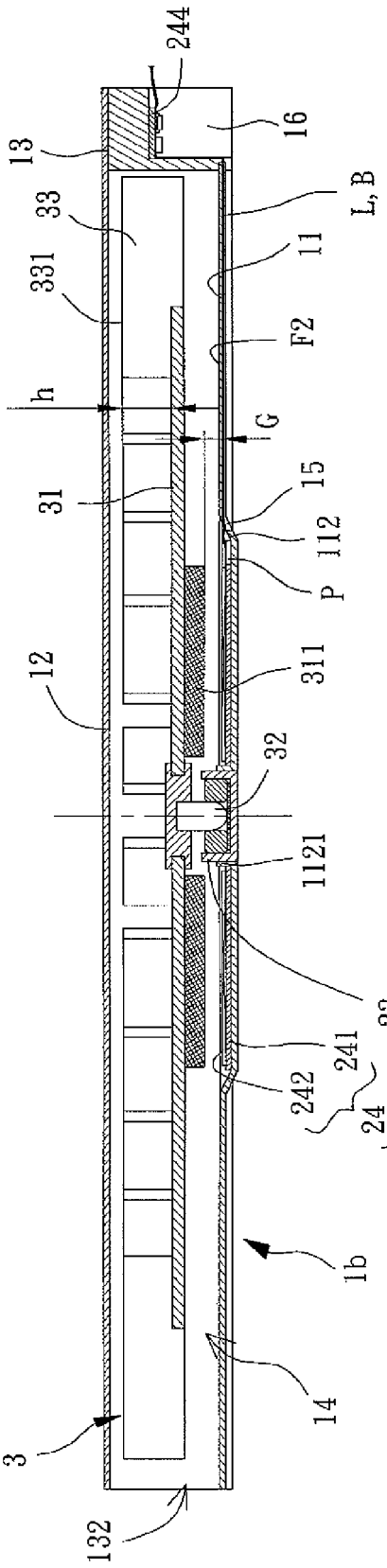
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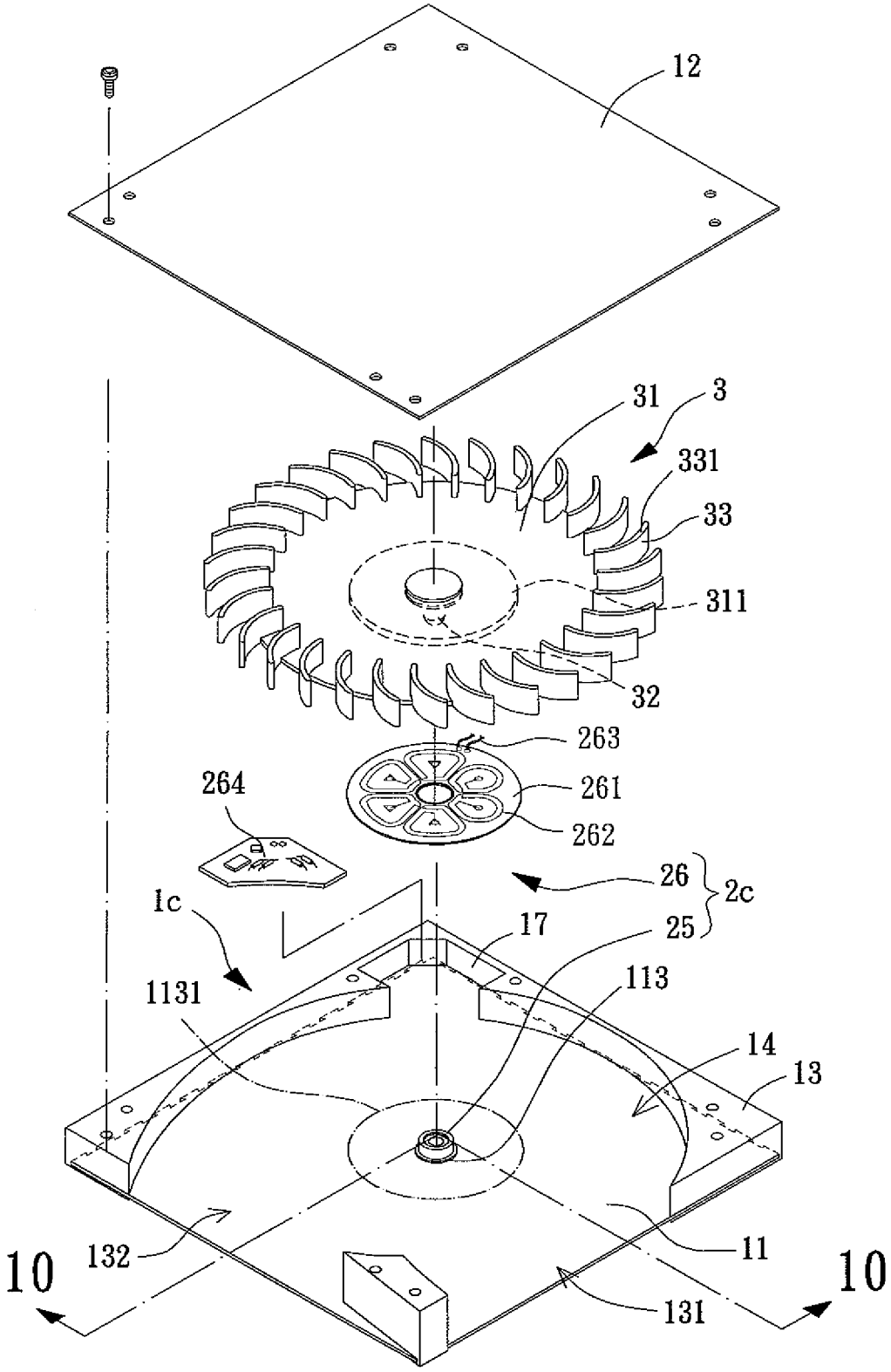
FIG. 8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131
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FIG. 9

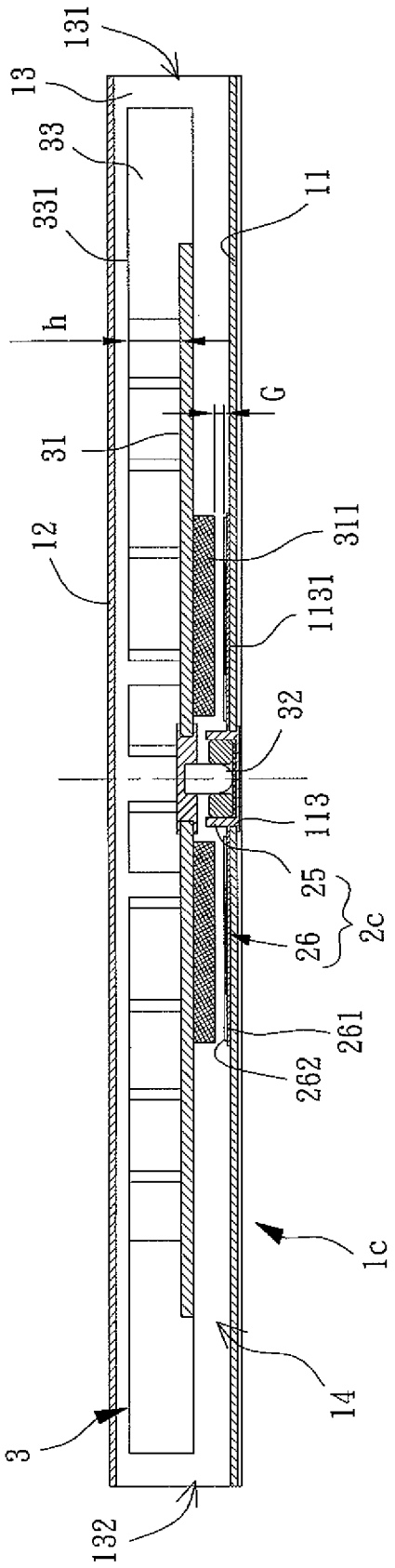
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FIG. 10

ADVECTION FANS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to advection fans and, more particularly, to advection fans that allow air currents to enter and exit in a direction perpendicular to an axial direction.

2. Description of the Related Art

Conventional cooling fans generally include axial fans and blower fans. An axial fan generally includes an axial air inlet and an axial air outlet spaced in an axial direction. Air currents are guided into the axial air inlet and then exit from the axial air outlet to provide a cooling function. A blower fan generally includes an axial air inlet and a radial air outlet. Air currents are guided into the axial air inlet and then exit from the radial air outlet to provide the cooling function.

However, axial fans can only guide air currents to flow in the axial direction for cooling purposes. Namely, axial fans can not guide air currents to flow in the radial direction. Thus, the axial fans must be mounted on top of a heat source (such as on a top face of a central processing unit of a personal computer) when used in various electronic products, such that the overall axial height of the electronic products can not be reduced. Although blower fans can guide air currents to exit from the radial air outlet, the air currents must be guided into the blower fans via the axial air inlet. As a result, the blower fans are not suitable for electronic products (such as cell phones, personal digital assistants, etc,) that must guide the air currents in lateral direction into a lateral side of the electronic product.

Namely, axial fans and blower fans currently available in the market can not be applied in small electronic products having limited inner spaces.

Taiwan Patent Publication No. 553323 discloses an advection fan that guides air currents in and out in a radial direction. Such an advection fan is more suitable for small electronic products that guide the air currents into the lateral side.

FIG. **1** shows another advection fan **9** including a housing **91** and an impeller **92**. The housing **91** includes an air passage **911** receiving a stator **93**. The stator **93** includes a shaft seat **931**, silicon steel plates **932** mounted around the shaft seat **931**, coils **933**, and insulating bobbins **934**. The impeller **92** is rotatably coupled to the shaft seat **931**. The stator **93** drives the impeller **92** to rotate to drive air currents to enter an end of the passage **911** and exit from the other end of the passage **911**, providing a cooling function.

The advection fan **9** is used in small electronic products and is miniaturized in the volume and the axial height of the housing **91**. However, the passage **911** must receive the stator **93** that includes the silicon steel plates **932**, the coils **933**, and the insulating bobbins **934** and, thus, occupies a considerable space in the passage **911**. The air guiding space in the miniaturized housing **91** is insufficient for guiding air currents, leading to a significant decrease in the air output and the wind pressure. Furthermore, unnecessary noise could occur due to hindrance to the air currents by the silicon steel plates **932**, the coils **933**, and the insulating bobbins **934**. Further, the housing **91** must include a predetermined axial height "H" to provide sufficient room for receiving the stator **93**. As a result, the volume and the axial height "H" of the housing **91** for receiving the stator **93** can not be further reduced while assuring sufficient space for guiding air currents. Namely, development and research in miniaturization of the advection fan **9** of this type is impossible. Further, the impeller **92** mounted in the passage **911** must be in the form of a hub to receive the stator **93**. Thus, the air currents are hindered by a large portion of the hub while flowing through the passage **911**, causing turbulence and resulting in considerable insufficiency in the air output and the wind pressure, significantly and adversely affecting the overall cooling effect of the advection fan **9**.

SUMMARY OF THE INVENTION

An objective of the present invention is to provide an advection fan in which the stator does not occupy much space of the advection fan, effectively increasing the air output and the wind pressure while reducing unnecessary noise.

Another objective of the present invention is to provide an advection fan that includes a housing having a reduced axial height, allowing development and research in miniaturization.

A further objective of the present invention is to provide an advection fan including an impeller that guides air currents in and out in a radial direction to reduce hindrance to the air currents by the stator, increasing the cooling effect.

The present invention fulfills the above objectives by providing, in a first aspect, an advection fan includes a housing having a metal housing base and a closure member. A lateral wall is arranged between the metal housing base and the closure member and includes an air inlet and an air outlet. A horizontal air passage is defined between the metal housing base and the closure member. The metal housing base includes an engagement section having a through-hole. A stator includes a shaft seat and a coil unit. The shaft seat integrally wraps the through-hole of the metal housing base. The shaft seat includes a compartment having a shaft coupling portion. The coil unit is embedded in the compartment. The coil unit includes a substrate having at least one coil unit formed on a surface of the substrate by a printing circuit or electroforming process. An impeller is rotatably coupled to the shaft coupling portion of the shaft seat of the stator. A gap is formed between the impeller and the coil unit of the stator.

In a second aspect, an advection fan includes a housing having a metal housing base and a closure member. A lateral wall is arranged between the metal housing base and the closure member and includes an air inlet and an air outlet. A horizontal air passage is defined between the metal housing base and the closure member. The metal housing base includes an engagement section having a recess. The recess includes a bottom having a fixing hole. A stator includes a shaft tube and a coil unit. The shaft tube is fixed in the fixing hole of the recess. The coil unit is embedded in the recess. The coil unit includes a substrate having at least one coil unit formed on a surface of the substrate by a printing circuit or electroforming process. An impeller is rotatably coupled to the shaft tube of the stator. A gap is formed between the impeller and the coil unit of the stator.

In a third aspect, an advection fan includes a housing having a metal housing base and a closure member. A lateral wall is arranged between the metal housing base and the closure member and includes an air inlet and an air outlet. A horizontal air passage is defined between the metal housing base and the closure member. The metal housing base includes an engagement section. The engagement section includes a shaft receiving hole and an engagement face surrounding the shaft receiving hole. A stator includes a shaft tube and a coil unit. The shaft tube is fixed in the shaft receiving hole. The coil unit abuts the engagement face of the metal housing base. The coil unit includes a substrate having at least one coil unit formed on a surface of the substrate by a printing circuit or electroforming process. An impeller is rotatably coupled to the shaft tube of the stator. A gap is formed between the impeller and the coil unit of the stator.

In a fourth aspect, an advection fan includes a housing having a metal housing base and a closure member. A lateral wall is arranged between the metal housing base and the closure member and includes an air inlet and an air outlet. A horizontal air passage is defined between the metal housing base and the closure member. The metal housing base includes an engagement section. A stator includes a coil unit embedded in or abutting and attached to the engagement section of the metal housing base. The coil unit abuts the engagement face of the metal housing base. The coil unit includes a substrate having at least one coil unit formed on a surface of the substrate by a printing circuit or electroforming process. An impeller is rotatably coupled to the shaft tube of the stator. A gap is formed between the impeller and the coil unit of the stator.

In an example, the impeller includes a metal impeller base, a shaft, and a plurality of vanes. The metal impeller base includes a permanent magnet facing the coil unit. The gap is an axial gap between the permanent magnet and the coil unit. The shaft is coupled to a central portion of the metal impeller base and rotatably coupled to the shaft coupling portion of the shaft seat. The plurality of vanes is engaged with the metal impeller base.

Each of the plurality of vanes includes a top edge in an axial direction of the shaft. The top edge of each of the plurality of vanes faces the closure member, with an axial height difference existing between the top edge of each of the plurality of vanes and the metal impeller base.

The plurality of vanes can be plastic vanes integrally formed with an outer periphery of the metal impeller base.

In an example, the metal housing base includes a wire hole. The at least one coil of the coil unit is electrically connected to a power cable. The power cable extends through the wire hole and is electrically connected to a driving circuit.

In another example, the metal housing base includes a wire hole. The at least one coil of the coil unit is electrically connected to a power cable. The lateral wall includes a receiving portion receiving a driving circuit. The power cable extends through the wire hole and extends along a bottom side of the housing into the receiving portion and is electrically connected to the driving circuit.

The receiving portion can be a cavity defined in the lateral wall.

In another example, the at least one coil of the coil unit is electrically connected to a power cable. The lateral wall includes an inner face having a notch. A driving circuit is received in the notch. The power cable extends along the metal housing base into the notch and is electrically connected to the driving circuit.

The lateral wall can be a plastic wall integrally wrapping an outer periphery of the metal housing base.

The shaft seat includes a face facing the closure member and defining a shaft seat reference face. The at least one coil of the coil unit has a top face flush with or below the shaft seat reference face.

The metal housing base includes the through-hole having a serrated inner periphery or includes at least one smaller through-hole adjacent to the through-hole.

In an example, the engagement face corresponds to the area of the permanent magnet in an axial direction of the shaft.

The present invention will become clearer in light of the following detailed description of illustrative embodiments of this invention described in connection with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The illustrative embodiments may best be described by reference to the accompanying drawings where:

FIG. **1** shows a cross sectional view of a conventional advection fan.

FIG. **2** shows an exploded, perspective view of an advection fan of a first embodiment according to the present invention.

FIG. **3** shows a cross sectional view of the advection fan of the first embodiment observed at line **3-3** in FIG. **2**.

FIG. **4** shows an exploded, perspective view of an advection fan of a second embodiment according to the present invention.

FIG. **5** shows a cross sectional view of the advection fan of the second embodiment observed at line **5-5** in FIG. **4**.

FIG. **6** shows another cross sectional view of the advection fan of the second embodiment observed at line **6-6** in FIG. **4**.

FIG. **7** shows an exploded, perspective view of another example of the advection fan of the second embodiment according to the present invention.

FIG. **8** shows a cross sectional view of the advection fan of the second embodiment observed at line **8-8** in FIG. **7**.

FIG. **9** shows an exploded, perspective view of an advection fan of a third embodiment according to the present invention.

FIG. **10** shows a cross sectional view of the advection fan of the second embodiment observed at line **10-10** in FIG. **9**.

All figures are drawn for ease of explanation of the basic teachings of the present invention only; the extensions of the figures with respect to number, position, relationship, and dimensions of the parts to form the preferred embodiments will be explained or will be within the skill of the art after the following teachings of the present invention have been read and understood. Further, the exact dimensions and dimensional proportions to conform to specific force, weight, strength, and similar requirements will likewise be within the skill of the art after the following teachings of the present invention have been read and understood.

DETAILED DESCRIPTION OF THE INVENTION

An advection fan of a first embodiment according to the present invention is shown in FIGS. **2** and **3** and includes a housing **1***a*, a stator **2***a*, and an impeller **3**. The housing **1***a* is configured to allow air currents to flow in a radial direction. The stator **2***a* is mounted to the housing **1***a*. The impeller **3** is rotatably coupled to the stator **2***a* and can be driven by the stator **2***a* to rotate.

The housing **1***a* can be any hollow frame that receives the stator **2***a* and the impeller **3** and that guides air currents in and out in the radial direction. The housing **1***a* can be of any geometric shape, such as polygonal, cylindrical, or elliptic. In this embodiment, the housing **1***a* is rectangular in a top view thereof.

The housing **1***a* includes a metal housing base **11** and a closure member **12** spaced from the metal housing base **11** in an axial direction. A lateral wall **13** is provided between the metal housing base **11** and the closure member **12** and includes an air inlet **131** and an air outlet **132** spaced from the air inlet **131** in a horizontal direction (as viewed from the drawings) that is perpendicular to the axial direction, forming a housing structure allowing air currents to flow in the horizontal direction. The housing structure is closed in the upper and lower ends (as viewed from the drawings), forming a horizontal air passage **14** between the metal housing base **11** and the closure member **12**. The number and locations of the air inlet **131** and the air outlet **132** can be varied according to needs. The engagement and formation of the metal housing base **11**, the closure member **12**, and the lateral wall **13** are not limited. In this embodiment, the lateral wall **13** is formed by

injection molding and wraps an outer periphery of the metal housing base **11**, and the closure member **12** is in the form of a cover detachably mounted to the lateral wall **13**.

The metal housing base **11** further includes an engagement section that can be any structure allowing embedding or abutment/attachment of the stator **2***a*. In this embodiment, the engagement section includes a through-hole **111** extending through the metal housing base **11**. Preferably, the through-hole **111** includes a serrated inner periphery (FIG. **2**). In another example, the metal housing base **11** includes at least one smaller through-hole adjacent to the through-hole **111** to allow engagement with the stator **2***a*, so that the stator **2***a* can be more reliably engaged in the through-hole **111** of the metal housing base **11**. Furthermore, the metal housing base **11** preferably includes a wire hole **15** for electrical connection with the stator **2***a*, which will be described in detail later.

The stator **2***a* includes a shaft seat **21** and a coil unit **22**. The shaft seat **21** includes a compartment **211** in which a shaft coupling portion **212** is mounted. The shaft coupling portion **212** can be any structure for coupling with the impeller **3** to allow smooth rotation of the impeller **3**. The coil unit **22** is embedded in the compartment **211** and includes a substrate **221**. At least one coil **222** is formed on a surface of the substrate **221** by a printing circuit or electroforming process. The coil **222** is electrically connected to a driving circuit (not shown) that can be directly mounted on the substrate **221**. However, the driving circuit can be mounted in other locations of the housing **1***a* or outside of the housing **1***a*. In this embodiment, the coil **222** is connected by a power cable **223** to the driving circuit. An end of the power cable **223** preferably extends through the wire hole **15** to the driving circuit. By such an arrangement, the power cable **223** can extend outside of the housing la and, thus, will not occupy much of the air guiding space of the air passage **14**, avoiding the air currents from being hindered by the power cable **223**.

Preferably, the shaft seat **21** is made of plastic material, and the shaft seat **21** wraps and engages with the inner periphery of the through-hole **111** (the engagement section) of the metal housing base **11** by injection molding. Loosening of the shaft seat **21** can be effectively avoided if the inner periphery of the through-hole **111** is serrated (FIG. **2**) or one or more smaller through-holes are formed adjacent to the through-hole **111**. With reference to FIG. **3**, a face of the shaft seat **21** facing the closure member **12** is defined as a shaft seat reference face "F**1**." By embedding the coil unit **22** in the compartment **211**, a top face of the coil **222** of the coil unit **22** facing the closure member **12** is preferably flush with or below the shaft seat reference face "F**1**." Thus, only a portion of the shaft coupling portion **212** of the stator **2***a* is located in the air passage **14**, avoiding the stator **2***a* from occupying much of the air guiding space of the air passage **14**. As a result, the air passage **14** has a sufficient air guiding space for guiding air currents.

The impeller **3** is rotatably coupled to the shaft seat **21** of the stator **2***a*. The impeller **3** can be of any type. In this embodiment, an axial gap "G" is formed between the impeller **3** and the stator **2***a*. Compared to conventional advection fans using a radial air gap for driving purposes, the advection fan according to the present invention can effectively reduce the overall volume and structural complexity by using the axial gap "G" for driving purposes, further reducing the volume and the axial height of the impeller **3**. In this embodiment, the impeller **3** includes a metal impeller base **31**, a shaft **32**, and a plurality of vanes **33**. A permanent magnet **311** is mounted to the metal impeller base **31**. With reference to FIG. **3**, the permanent magnet **311** faces and is spaced from the coil unit **22** in the axial direction to form the axial gap "G." The metal impeller base **31** serves as a magnetism sealing board. The shaft **32** is coupled to a central portion of the metal impeller base **31** and rotatably engaged with the shaft coupling portion **212** of the shaft seat **21**. The vanes **33** are engaged with an outer periphery of the metal impeller base **31**. Preferably, the vanes **33** are plastic to be integrally formed with the outer periphery of the metal impeller base **31**. Each vane **33** includes a top edge **331** in the axial direction of the shaft **32**, with the top edge **331** facing the closure member **12**, and with an axial height difference "h" existing between the top edge **331** and the metal impeller base **31**. By providing the axial height difference "h," the air currents driven by the impeller **3** in the horizontal direction can pass above the metal impeller base **31** without hindrance. Thus, the impeller **3** can more smoothly guide air currents to flow through the interior of the housing **1***a* by utilizing the horizontal air guiding space, reducing the noise resulting from turbulence and significantly increasing the cooling effect.

In use of the advection fan according to the present invention, the coil **222** of the coil unit **22** of the stator **2***a* creates an alternating magnetic field that cooperates with the permanent magnet **311** to drive the impeller **3** to rotate. Thus, the advection fan according to the present invention can be used in various electronic products, with the vanes **33** guiding ambient air currents into the interior of the housing **1***a* via the air inlet **131** and then exiting from the air outlet **132** to the outside, providing the desired cooling effect for the heat sources generated during operation of the electronic products.

The first embodiment of the advection fan according to the present invention includes many features. Firstly, the metal housing base **11** of the housing **1***a* can be made of a thin metal sheet providing certain strength. Thus, the structural strength of the fan housing **1***a* still meets the standards for strength, although the housing **1***a* is thin. Furthermore, the coil **222** of the stator **2***a*can be formed on the surface of the substrate **221** by a printing circuit or electroforming process to further reduce the axial height of the stator **2***a*. Since the stator **2***a* is engaged with the through-hole **111** (the engagement section) and since the coil unit **22** of the stator **2***a* is embedded in the compartment **211**, only the shaft coupling portion **212** of the stator **2***a* is located in the air passage **14**. Overall, by the structural arrangement of the housing **1***a* and the stator **2***a* according to the present invention, the stator **2***a* will not occupy much space in the air passage **14**, such that the air guiding space of the air passage **14** can be effectively used. When the impeller **3** guides the air currents to flow through the air passage **14**, the air output and the wind pressure of the impeller **3** can be increased while effectively reducing the hindrance to the air currents by the stator **2***a*, avoiding unnecessary noise. Further, the axial height of the advection fan according to the present invention can be reduced effectively, allowing development and research in miniaturization.

FIGS. **4** and **5** show an advection fan of a second embodiment according to the present invention. Similar to the first embodiment, the second embodiment includes a housing **1***b*, a stator **2***b*, and an impeller **3**. The housing **1***b* is substantially the same as the housing **1***a* and includes a metal housing base **11**, a closure member **12**, a lateral wall **13**, an air inlet **131**, an air outlet **132**, an air passage **14**, and a wire hole **15**. The structural features of the housing **1***b* and the impeller **3** of the second embodiment identical to those of the housing **1***a* and the impeller **3** will not be described in detail to avoid redundancy.

The difference between the housing **1***b* of the second embodiment and the housing **1***a* of the first embodiment is that the engagement section of the metal housing base **11** of the housing **1***b* for coupling with the stator **2***b* (by embedding

or abutment/attachment) is in the form of a recess **112** formed in the surface of the metal housing base **11** by punching. The recess **112** includes a bottom having a fixing hole **1121** in a center thereof. The lateral wall **13** includes a receiving portion **16** to cooperate with the wire hole **15**. In an example shown in FIGS. **4** and **6**, the receiving portion **16** is in the form of a cavity defined in a top side of the lateral wall **13**. In another example shown in FIGS. **7** and **8**, the receiving portion **16** is in the form of a cavity defined in a bottom side of the lateral wall **13**. The receiving portion **16** can receive a driving circuit or the like.

The stator **2***b* of the second embodiment is embedded in the recess **112** of the metal housing base **11**. The stator **2***b* includes a shaft tube **23** and a coil unit **24**. An end of the shaft tube **23** is fixed in the fixing hole **1121** of the recess **112**. The shaft **32** of the impeller **3** is rotatably coupled to the other end of the shaft tube **23**. The shaft tube **23** can be fixed in the fixing hole **1121** by tight fitting, welding, male/female coupling, thread engagement, etc. The coil unit **24** is embedded in the recess **112** of the metal housing base **11** and includes a substrate **241** that has at least one coil **242** formed on a surface of the substrate **241** by a printing circuit or electroforming process.

In the example shown in FIG. **6** in which the receiving portion **16** is a cavity defined in the top side of the lateral wall **13**, the coil **242** can be connected by a power cable **243** to a driving circuit **244** that is received in the receiving portion **16** of the housing **1***b*. An end of the power cable **243** preferably extends through the wire hole **15** of the metal housing base **11** of the housing **1***b* and extends along a bottom side of the housing **1***b* into the receiving portion **16** to connect the driving circuit **244**. By such an arrangement, the power cable **243** will not occupy much of the air guiding space of the air passage **14**, avoiding hindrance to the air currents by the power cable **243**. With the driving circuit **244** received in the receiving portion **16**, the limited space of the housing **1***b* can be used more effectively.

In the example shown in FIGS. **7** and **8** in which the receiving portion **16** is a cavity defined in the bottom side of the lateral wall **13**, the bottom side of the metal housing base **11** of the housing **1***b* can include a wire groove "L" extending between the wire hole **15** and the receiving portion **16** and receiving a flexible flat cable "B." Thus, the power cable **243** in FIG. **6** is not necessary. The substrate **241** of the stator **2***b* includes a port "P" electrically connected to the coil **242** and extending out of the wire hole **15**. The driving circuit **244** is received in the receiving portion **16** and electrically connected by the flexible flat cable "B" to the port "P." The flexible flat cable "B" can be detachably attached to or integrally formed with the driving circuit **244**.

With reference to FIG. **5**, a face of the metal housing base **11** facing the closure member **12** is defined as a base reference face "F**2**." By embedding the coil unit **24** in the recess **112** of the metal housing base **11**, a top face of the coil **242** facing the closure member **12** is preferably flush with or below the base reference face "F**2**." Thus, only the other end of the stator **2***b* having the shaft tube **23** is located in the air passage **14**, avoiding the stator **2***b* from occupying too much of the air guiding space of the air passage **14**.

The second embodiment of the advection fan according to the present invention includes many features. Firstly, the metal housing base **11** of the housing **1***b* can be made of a thin metal sheet providing a certain strength. Furthermore, the coil **242** of the stator **2***b* can be formed on the surface of the substrate **241** by a printing circuit or electroforming process to further reduce the axial height of the stator **2***b*. Since the stator **2***b* is embedded in the recess **112** of the metal housing base **11**, only the other end of the stator **2***b* having the shaft tube **23** is located in the air passage **14**. Overall, by the structural arrangement of the housing lb and the stator **2***b* according to the present invention, the stator **2***b* will not occupy much space in the air passage **14**, such that the air guiding space of the air passage **14** can be effectively used, increasing the air output and the wind pressure of the impeller **3**. Unnecessary noise and the axial height of the advection fan can effectively be reduced, allowing development and research in miniaturization.

FIGS. **9** and **10** show an advection fan of a third embodiment according to the present invention. Similar to the first embodiment, the third embodiment includes a housing **1***c*, a stator **2***c*, and an impeller **3**. The housing **1***c* is substantially the same as the housing **1***a* and includes a metal housing base **11**, a closure member **12**, a lateral wall **13**, an air inlet **131**, an air outlet **132**, and an air passage **14**. The structural features of the housing **1***c* and the impeller **3** of the third embodiment identical to those of the housing **1***a* and the impeller **3** will not be described in detail to avoid redundancy.

The difference between the housing **1***c* of the third embodiment and the housing **1***a* of the first embodiment is that the engagement section of the metal housing base **11** of the housing **1***c* for coupling with the stator **2***c* by abutment/attachment includes a shaft receiving hole **113** and an engagement face **1131** surrounding the shaft receiving hole **113**. Preferably, the engagement face **1131** corresponds to the area of the permanent magnet **311**. Preferably, the lateral wall **13** includes an inner face having a notch **17** for receiving a driving circuit or the like, which will be described in detail later.

The stator **2***c* of the third embodiment is attached to and abuts the engagement section (including the shaft receiving hole **113** and the engagement face **1131**) of the metal housing base **11**. The stator **2***c* includes a shaft tube **25** and a coil unit **26**. An end of the shaft tube **25** is fixed in the shaft receiving hole **113**. The shaft **32** of the impeller **3** is rotatably coupled to the other end of the shaft tube **25**. The shaft tube **25** can be fixed in the shaft receiving hole **113** by tight fitting, welding, male/female coupling, thread engagement, etc. In this embodiment, the shaft tube **25** is formed by injection molding and wraps the inner periphery of the shaft receiving hole **113**, thereby engaging with the shaft receiving hole **113**. The coil unit **26** abuts the engagement face **1131** of the metal housing base **11**. The coil unit **26** includes a substrate **261**, with at least one coil **262** formed on a surface of the substrate **261** by a printing circuit or electroforming process. In this embodiment, the coil **262** is connected by a power cable **263** to a driving circuit **264** that is received in the notch **17** of the housing **1***c*. With reference to FIG. **9**, the housing **1***c* of this embodiment does not have to include the wire hole **15** in the first and second embodiments. Instead, the power cable **263** abuts the surface of the metal housing base **11** and extends into the notch **17**, allowing easy connection to the driving circuit **264** in assembly. With the driving circuit **264** received in the notch **17**, the limited space of the housing **1***c* can effectively be used.

The third embodiment of the advection fan according to the present invention includes many features. Firstly, the metal housing base **11** of the housing **1***c* can be made of a thin metal sheet providing a certain strength. Furthermore, the coil **262** of the stator **2***c* can be formed on the surface of the substrate **261** by a printing circuit or electroforming process to further reduce the axial height of the stator **2***c*. Since the stator **2***c* is engaged with the engagement section (including the shaft receiving hole **113** and the engagement face **1131**) of the metal housing base **11**, only the other end of the stator **2***c* having the shaft tube **25** is located in the air passage **14**.

Overall, by the structural arrangement of the housing **1***c* and the stator **2***c* according to the present invention, the stator **2***c* will not occupy much space in the air passage **14** such that the air guiding space of the air passage **14** can be effectively used, increasing the air output and the wind pressure of the impeller **3**. Unnecessary noise and the axial height of the advection fan can effectively be reduced, allowing development and research in miniaturization.

Conclusively, the advection fans of the present invention provide many advantages based on the structural designs of the advection fans of the first, second, and third embodiments.

1. The Space in the Air Passage **14** can Effectively be Utilized.

When using the advection fans according to the present invention in small electronic products, the volume and the axial height of the housing **1***a*, **1***b*, **1***c* are miniaturized. Since the stator **2***a*, **2***b*, **2***c* is embedded or attached to and abuts the engagement section of the thin metal housing base **11** and since the coil **222**, **242**, **262** of the stator **2***a*, **2***b*, **2***c* is formed on a surface of the substrate **221**, **241**, **261** by a printing circuit or electroforming process, the volume and the axial height of the stator **2***a*, **2***b*, **2***c* can be further reduced. More specifically, only the shaft coupling portion **212** or the shaft tube **23**, **25** of the stator **2***a*, **2***b*, **2***c* according to the present invention is located in the air passage **14**, such that the stator **2***a*, **2***b*, **2***c* does not occupy much space in the air passage **14**. Compared to, conventional advection fans having a horizontal air passage, the present invention can effectively increase the air guiding space of the air passage **14**, increase the air output and the wind pressure, and reduce noise.

2. Development and Research in Miniaturization.

Since the stator **2***a*, **2***b*, **2***c* does not occupy much space in the air passage **14**, the housing **1***a*, **1***b*, **1***c* does not have to increase the space for receiving the stator **2***a*, **2***b*, **2***c*. Namely, the housing **1***a*, **1***b*, **1***c* according to the present invention can be easily reduced in the volume and the axial height, allowing development and research in miniaturization.

3. Excellent Cooling Effect.

Since the stator **2***a*, **2***b*, **2***c* according to the present invention as a whole is relatively thin, the impeller **3** of the advection fan according to the present invention does not have to be in the form of a hub for receiving the stator **2***a*, **2***b*, **2***c*. Thus, when the impeller **3** is guiding air currents to flow through the air passage to provide convection, the air currents will not be hindered by the impeller **3**, avoiding turbulence and increasing the cooling effect. Furthermore, in the case that the metal impeller base **31** of the impeller **3** is coupled with the shaft **32** and the vanes **33** as shown in the previous embodiments, the reduction of turbulence and increase of the cooling effect are more obvious during guiding of the air currents by the impeller **3** in the horizontal direction.

Thus since the invention disclosed herein may be embodied in other specific forms without departing from the spirit or general characteristics thereof, some of which forms have been indicated, the embodiments described herein are to be considered in all respects illustrative and not restrictive. The scope of the invention is to be indicated by the appended claims, rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are intended to be embraced therein.

What is claimed is:

1. An advection fan comprising:

a housing including a metal housing base and a closure member, with a lateral wall arranged between the metal housing base and the closure member and including an air inlet and an air outlet, with a horizontal air passage defined between the metal housing base and the closure member, with the metal housing base including an engagement section;

a stator including a shaft seat and a coil unit, with the shaft seat attached to the engagement section, with the shaft seat including a shaft coupling portion and a bottom wall extending radially outward of the shaft coupling portion to an outer rim extending axially from the bottom wall and terminating in a face facing the closure member, with the face of the outer rim defining a shaft seat reference face, with the shaft coupling portion, the bottom wall, and the outer rim defining a compartment, with the coil unit embedded in the compartment, with the coil unit including a substrate and at least one coil formed on a surface of the substrate, with the substrate intermediate the at least one coil and the bottom wall, with the at least one coil of the coil unit having a top face flush with or below the shaft seat reference face; and

an impeller rotatably coupled to the shaft coupling portion of the shaft seat of the stator, with a gap formed between the impeller and the coil unit of the stator.

2. The advection fan as claimed in claim **1**, with the engagement section including a through-hole, with the shaft seat integrally wrapping the through-hole of the metal housing base, with the at least one coil formed on the surface of the substrate by a printing circuit or electroforming process.

3. The advection fan as claimed in claim **1**, with the impeller including a metal impeller base, a shaft, and a plurality of vanes, with the metal impeller base including a permanent magnet facing the coil unit, with the gap being an axial gap between the permanent magnet and the coil unit, with the shaft coupled to a central portion of the metal impeller base and rotatably coupled to the shaft coupling portion of the shaft seat, with the plurality of vanes engaged with the metal impeller base.

4. The advection fan as claimed in claim **3**, with each of the plurality of vanes including a top edge extending radially to an axial direction of the shaft, with the top edge of each of the plurality of vanes facing the closure member, with an axial height difference existing between the top edge of each of the plurality of vanes and the metal impeller base.

5. The advection fan as claimed in claim **3**, with the plurality of vanes being plastic vanes integrally formed with an outer periphery of the metal impeller base.

6. The advection fan as claimed in claim **1**, with the metal housing base including a wire hole, with the at least one coil of the coil unit electrically connected to a power cable, with the power cable extending through the wire hole and electrically connected to a driving circuit.

7. The advection fan as claimed in claim **1**, with the metal housing base including a wire hole, with the at least one coil of the coil unit electrically connected to a power cable, with the lateral wall including an inner face, an outer face opposite to the inner face, and a receiving portion extending from the inner face towards but spaced from the outer face and communicating with the horizontal air passage, with the receiving portion receiving a driving circuit, with the power cable extending through the wire hole and extending along a bottom side of the housing into the receiving portion and electrically connected to the driving circuit.

8. The advection fan as claimed in claim **7**, with the receiving portion being a cavity defined in the lateral wall.

9. The advection fan as claimed in claim **1**, with the at least one coil of the coil unit electrically connected to a power cable, with the lateral wall including an inner face, an outer face opposite to the inner face, and a notch extending from the inner face towards but spaced from the outer face and com-

municating with the horizontal air passage, with a driving circuit received in the notch, with the power cable extending along the metal housing base into the notch and electrically connected to the driving circuit.

10. The advection fan as claimed in claim **1**, with the lateral wall being a plastic wall integrally wrapping an outer periphery of the metal housing base.

11. The advection fan as claimed in claim **2**, with the metal housing base including the through-hole having a serrated inner periphery.

12. An advection fan comprising:

a housing including a metal housing base and a closure member, with a lateral wall arranged between the metal housing base and the closure member and including an air inlet and an air outlet with a horizontal air passage defined between the metal housing base and the closure member, with the metal housing base including an engagement section having a face facing the closure member and defining a base reference face and a recess, with the recess including a bottom having a fixing hole, with the base reference face being intermediate the bottom of the recess and the closure member;

a stator including a shaft tube and a coil unit, with the shaft tube fixed in the fixing hole of the recess, with the coil unit embedded in the recess, with the coil unit including a substrate and at least one coil formed on a surface of the substrate, with the at least one coil of the coil unit having a top face flush with or below the base reference face; and

an impeller rotatably coupled to the shaft tube of the stator, with a gap formed between the impeller and the coil unit of the stator.

13. The advection fan as claimed in claim **12**, with the impeller including a metal impeller base, a shaft, and a plurality of vanes, with the metal impeller base including a permanent magnet facing the coil unit, with the gap being an axial gap between the permanent magnet and the coil unit, with the shaft coupled to a central portion of the metal impeller base and rotatably coupled to the shaft tube, with the plurality of vanes engaged with the metal impeller base.

14. The advection fan as claimed in claim **13**, with each of the plurality of vanes including a top edge extending radially to an axial direction of the shaft, with the top edge of each of the plurality of vanes facing the closure member, with an axial height difference existing between the top edge of each of the plurality of vanes and the metal impeller base.

15. The advection fan as claimed in claim **13**, with the plurality of vanes being plastic vanes integrally formed with an outer periphery of the metal impeller base.

16. The advection fan as claimed in claim **12**, with the metal housing base including a wire hole, with the at least one coil of the coil unit electrically connected to a power cable, with the power cable extending through the wire hole and electrically connected to a driving circuit.

17. The advection fan as claimed in claim **12**, with the metal housing base including a wire hole, with the at least one coil of the coil unit electrically connected to a power cable, with the lateral wall including an inner face, an outer face opposite to the inner face, and a receiving portion extending from the inner face towards but spaced from the outer face and communicating with the horizontal air passage, with the receiving portion receiving a driving circuit, with the power cable extending through the wire hole and extending along a bottom side of the housing into the receiving portion and electrically connected to the driving circuit.

18. The advection fan as claimed in claim **17**, with the receiving portion being a cavity defined in the lateral wall.

19. The advection fan as claimed in claim **12**, with the at least one coil of the coil unit electrically connected to a power cable, with the lateral wall including an inner face, an outer face opposite to the inner face, and a notch extending from the inner face towards but spaced from the outer face and communicating with the horizontal air passage, with a driving circuit received in the notch, with the power cable extending along the metal housing base into the notch and electrically connected to the driving circuit.

20. The advection fan as claimed in claim **12**, with the lateral wall being a plastic wall integrally wrapping an outer periphery of the metal housing base.

21. An advection fan comprising:

a housing including a metal housing base and a closure member, with a lateral wall arranged between the metal housing base and the closure member and including an inner face, an outer face opposite to the inner face, an air inlet and an air outlet, with a horizontal air passage defined by the inner face of the lateral wall between the metal housing base and the closure member, with the metal housing base including an engagement section, with the engagement section including a shaft receiving hole and an engagement face surrounding the shaft receiving hole;

a stator including a shaft tube and a coil unit, with the shaft tube fixed in the shaft receiving hole, with the coil unit embedded in the engagement face of the metal housing base, with the coil unit including a substrate and at least one coil formed on a surface of the substrate, with the at least one coil of the coil unit electrically connected to a power cable, with the inner face having a notch extending from the inner face towards but spaced from the outer surface and communicating with the horizontal air passage;

a driving circuit received in the notch, with the power cable extending along the metal housing base into the notch and electrically connected to the driving circuit; and

an impeller rotatably coupled to the shaft tube of the stator, with a gap formed between the impeller and the coil unit of the stator.

22. The advection fan as claimed in claim **21**, with the impeller including a metal impeller base, a shaft, and a plurality of vanes, with the metal impeller base including a permanent magnet facing the coil unit, with the gap being an axial gap between the permanent magnet and the coil unit, with the shaft coupled to a central portion of the metal impeller base and rotatably coupled to the shaft tube, with the plurality of vanes engaged with the metal impeller base.

23. The advection fan as claimed in claim **22**, with each of the plurality of vanes including a top edge extending radially to an axial direction of the shaft, with the top edge of each of the plurality of vanes facing the closure member, with an axial height difference existing between the top edge of each of the plurality of vanes and the metal impeller base.

24. The advection fan as claimed in claim **22**, with the plurality of vanes being plastic vanes integrally formed with an outer periphery of the metal impeller base.

25. The advection fan as claimed in claim **21**, with the lateral wall being a plastic wall integrally wrapping an outer periphery of the metal housing base.

26. The advection fan as claimed in claim **22**, with the engagement face corresponding to an area of the permanent magnet in an axial direction of the shaft.

27. An advection fan comprising:

a housing including a metal housing base and a closure member, with a lateral wall arranged between the metal housing base and the closure member and including an

inner face, an outer face opposite to the inner face, an air inlet and an air outlet, with a horizontal air passage defined by the inner face of the lateral wall between the metal housing base and the closure member, with the metal housing base including an engagement section, with the metal housing base including a wire hole, with the lateral wall including a receiving portion extending from the inner face towards but spaced from the outer face and communicating with the horizontal air passage, with the receiving portion being a cavity defined in the lateral wall;

a stator including a coil unit embedded in the engagement section of the metal housing base, with the coil unit abutting the engagement face of the metal housing base, with the coil unit including a substrate and at least one coil formed on a surface of the substrate, with the at least one coil of the coil unit electrically connected to a power cable;

a driving circuit received in the cavity, with the power cable extending through the wire hole and extending along a bottom side of the housing into the receiving portion and electrically connected to the driving circuit; and

an impeller rotatably coupled to the shaft tube of the stator, with a gap formed between the impeller and the coil unit of the stator.

28. The advection fan as claimed in claim **27**, with the impeller including a metal impeller base, a shaft, and a plurality of vanes, with the metal impeller base including a permanent magnet facing the coil unit, with the gap being an axial gap between the permanent magnet and the coil unit, with the shaft coupled to a central portion of the metal impeller base and rotatably coupled to the stator, with the plurality of vanes engaged with the metal impeller base.

29. The advection fan as claimed in claim **28**, with each of the plurality of vanes including a top edge extending radially to an axial direction of the shaft, with the top edge of each of the plurality of vanes facing the closure member, with an axial height difference existing between the top edge of each of the plurality of vanes and the metal impeller base.

30. The advection fan as claimed in claim **28**, with the plurality of vanes being plastic vanes integrally formed with an outer periphery of the metal impeller base.

31. The advection fan as claimed in claim **27**, with the lateral wall being a plastic wall integrally wrapping an outer periphery of the metal housing base.

32. The advection fan as claimed in claim **27**, with the metal housing base including an engagement section having a face facing the closure member and defining a base reference face and a recess, with the recess including a bottom having a fixing hole, with the base reference face being intermediate the bottom of the recess and the, closure member, with the at least one coil of the coil unit having a top face flush with or below the base reference face.

33. An advection fan comprising:

a housing including a metal housing base and a closure member, with a lateral wall arranged between the metal housing base and the closure member and including an inner face, an outer face opposite to the inner face, an air inlet and an air outlet, with a horizontal air passage defined by the inner face of the lateral wall between the metal housing base and the closure member, with the metal housing base including an engagement section;

a stator including a coil unit embedded in the engagement section of the metal housing base, with the coil unit abutting the engagement face of the metal housing base, with the coil unit including a substrate and at least one coil formed on a surface of the substrate, with the at least one coil of the coil unit electrically connected to a power cable, with the inner face having a notch extending from the inner face towards but spaced from the outer face and communicating with the horizontal air passage;

a driving circuit received in the notch, with She power cable extending along the metal housing base into the notch and electrically connected to the driving circuit; and

an impeller rotatably coupled to the shaft tube of the stator, with a gap formed between the impeller and the coil unit of the stator.

34. The advection fan as claimed in claim **33**, with the engagement section including a through-hole, with the shaft seat integrally wrapping the through-hole of the metal housing base, with the at least one coil formed on the surface of the substrate by a printing circuit or electroforming process.

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